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October 14, 2004

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APPLICATION NUMBER: *60/505,384*
FILING DATE: *September 23, 2003*
RELATED PCT APPLICATION NUMBER: *PCT/US04/31274*

Certified by

Jon W Dudas

Acting Under Secretary of Commerce
for Intellectual Property
and Acting Director of the U.S.
Patent and Trademark Office

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a r qu st f r filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

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INVENTOR(S)

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☐ Additional inventors are being named on the ____ separately numbered sheets attached hereto

TITLE OF THE INVENTION (280 characters max)

Phtocurable Pefluoropolyethers for use as Novel Materials in Microfluidic Devices

Direct all correspondence to : **CORRESPONDENCE ADDRESS**

☒ Customer Number 000029690 → Place Customer Number Bar Code Label here 29690 PATENT TRADEMARK OFFICE

OR

ENCLOSED APPLICATION PARTS (check all that apply)

☒ Specification Number of Pages __3___ ☐ CD(s), Number

☐ Drawing(s) Number of Sheets _____

☐ Application Data Sheet. See 37 CFR 1.76 ☒ Other (specify) Postcard

METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☒ Applicant claims small entity status. See 37 CFR 1.27.

☐ A check or money order is enclosed to cover the filing fees.

☒ The Commissioner is hereby authorized to charge filing fees or credit any overpayment to Deposit Account Number: 50-1742

☐ Payment by credit card. Form PTO-2038 is attached.

FILING FEE AMOUNT ($): 80

The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☒ No

☐ Yes, the name of the U.S. Government agency and the contract number are:

Respectfully submitted,

SIGNATURE [signature]

Date 9/23/2003

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The PTO did not receive the following listed item(s) small entity status

09/23/03 19351 U.S.

22151 U.S. PTO 60/505384 09/23/03

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DESCRIPTION OF INVENTION:

Describe the invention in detail. Attach additional pages as necessary.

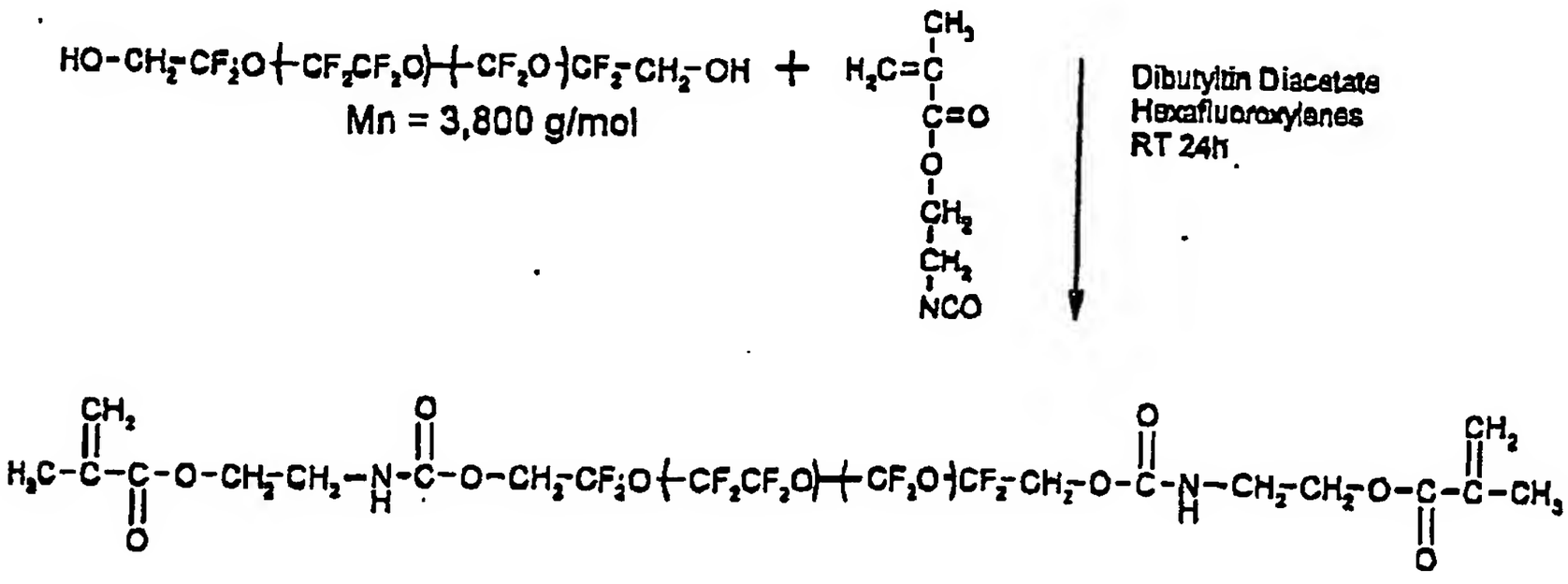
The invention described involves the use of photocurable perfluoropolyether materials to formulate microfluidic devices by soft lithography. Soft lithography is the process by which a liquid prepolymer is poured over a patterned silicon wafer. The liquid prepolymer is then crosslinked and when delaminated from the wafer creates a "stamp" of the desired pattern. PDMS materials are the current prepolymers of choice for such processes.

The increasing complexity of microfluidic devices has created a demand to use them in a rapidly growing number of applications. However, the swelling of the PDMS device by organic solvents drastically disrupts its micron-size features. Thus, these applications are limited to the use of fluids such as water that do not swell PDMS. A material that could be formulated into a microfluidic device that did not swell in typical organic solvents such as methylene chloride yet retained the mechanical properties of PDMS is greatly desired and could open the door to a wide variety of applications which are inaccessible by current PDMS materials.

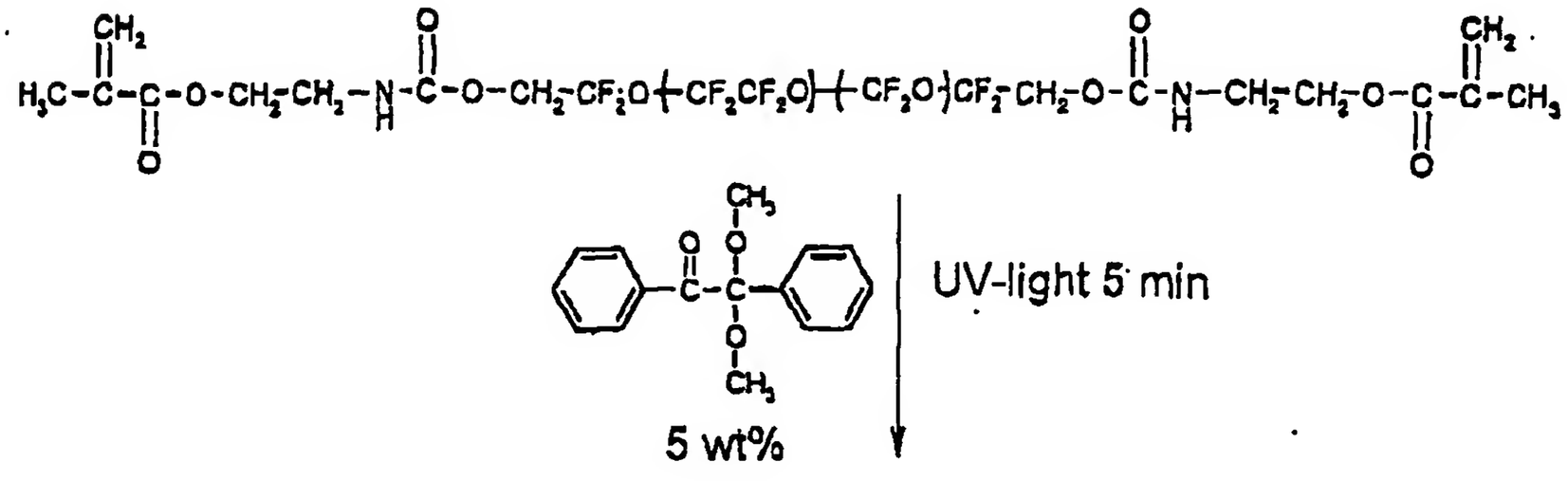
Perfluoropolyethers (PFPEs) are a class of fluoropolymers that are widely known for their hydrophobic and lyophobic properties. For this reason they are often employed as lubricants on high-performance machinery operating in harsh conditions. Since they have similar viscosities compared to Sylgard 184 prepolymers, they are ideal candidates for a novel class of solvent-resistant microfluidic devices.

Bongiovanni et. al. have previously reported the synthesis of functionalized UV-curable perfluoropolyethers (*Macromol. Chem. Phys.* 198, *1893-1907(1997)*). Using a slightly modified procedure, we have synthesized and cured the same materials. The novelty of this invention lies in the use of these materials in the fabrication of microfluidic devices. Shown below is an outline of our synthetic methodology.

Scheme 1. Synthesis of functionalized PFPE prepolymers



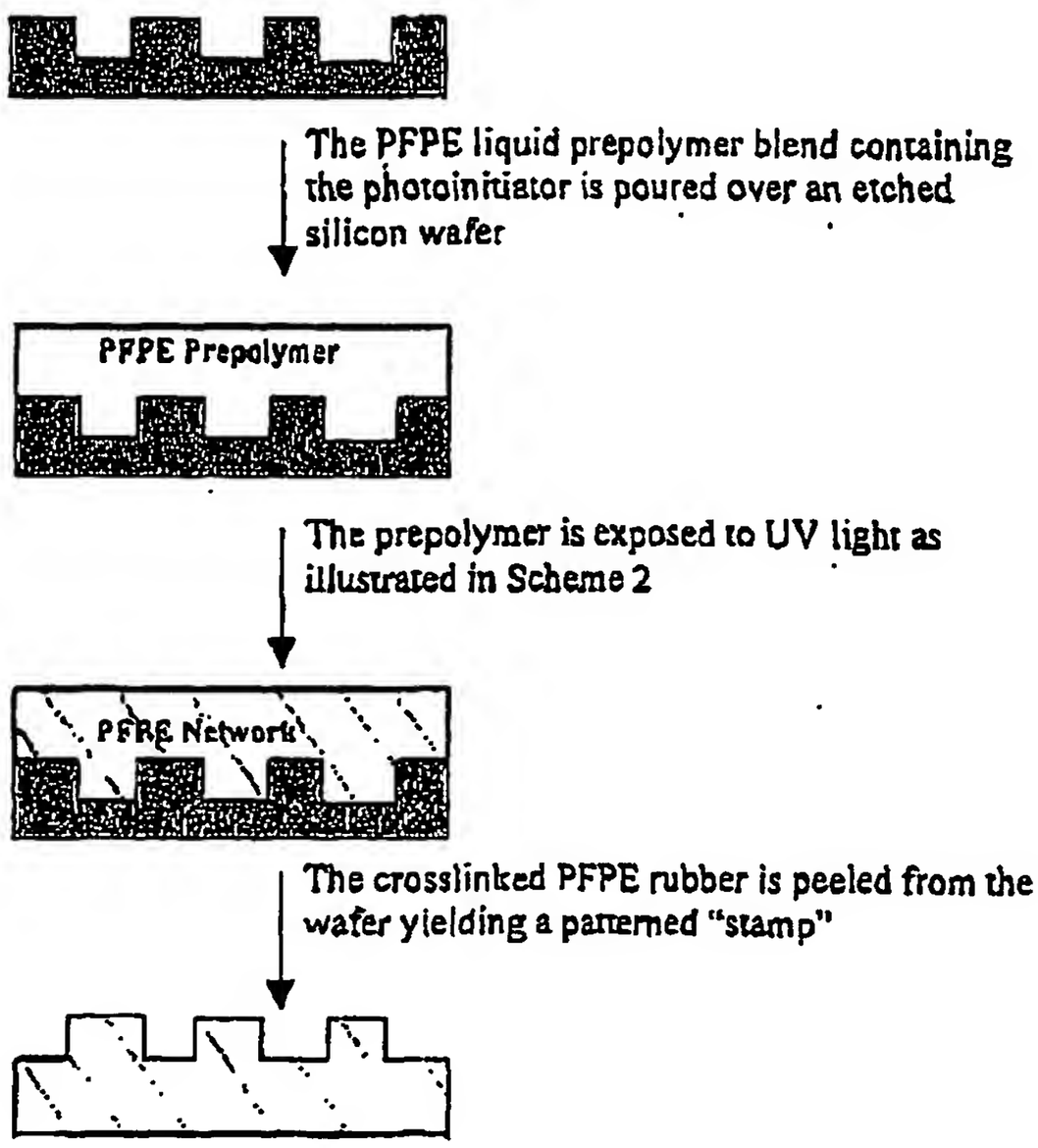
Once this functionalized material is isolated and purified, we are able to crosslink it photochemically through the addition of a free radical photoinitiator to form a miscible blend and subsequent exposure to UV light for five minutes. This procedure is outlined below.



Scheme 2. Photocuring of functionalized PFPE prepolymers

As was previously mentioned, the novelty of this invention is in the formation of microfluidic devices with this material using the described curing process. Shown in **Figure 1** is a cartoon illustration of how that process will occur.

Figure 1. Illustration of proposed device fabrication using UV-curable PFPE materials



a. Write a brief descriptive abstract of the invention without disclosing any confidential information. This may be used for marketing purposes.

The invention described involves the usage of novel functionalized PFPE materials in the fabrication of microfluidic devices by "soft lithography." These advanced materials will allow for the fabrication of devices that will enable microfluidics technology to expand into applications that are currently unreachable due to swelling of the current PDMS-based devices by organic solvents.

b. Expand on novel and unusual features which distinguish this invention from present technology. What problems does the invention solve or what advantages does it possess?

Our experiments have shown fully cured Sylgard 184 to swell up to 94 wt% in methylene chloride. Such swelling will seriously disrupt the micron-sized channels in microfluidic devices and render them useless. In contrast, our PFPE materials showed only 2 wt% swelling after soaking in methylene chloride for 5 days. The invention solves this swelling problem and allows for microfluidics technology to expand into novel applications that utilize organic solvents.

c. Comment on possible uses for the invention. In addition to immediate applications, are there other uses that might be realized in the future?

Microfluidics technology has far-reaching applications. In a recent article in *The Industrial Physicist* (August/September 2003, pg 14), Kevin Killeen of Agilent is quoted as saying " Microfluidics is going to revolutionize the way things are done... It's going to miniaturize chemistry and make possible chemical reactions that can't be done in batch mode today....it will touch virtually every aspect of our lives." The technology has found applications in ink-jet printers, lab-on-a-chip assays, pharmaceuticals, biotechnology, chemical sensors for defense, and agriculture. However, all of these applications are limited in that only fluids that do not swell Sylgard 184 can be used. The present invention opens the door to a wider span of applications through the lyophobic nature of the PFPE networks.

d. Describe any disadvantages or limitations of the invention. Can they be overcome? How?

The only disadvantage of the use of PFPE materials is the cost. PFPEs are much more expensive than PDMS materials. However, microfluidics technology utilizes only minute quantities of the prepolymer, thus the cost of these materials is virtually a non-issue.

e. Are there known inventions or products that would compete with this one? Please describe, including information on relevant patents and publications, if available.

As described previously, the PDMS prepolymers, commercially known as Sylgard 184 are the current materials of choice for microfluidics.

g. Are there any prior patent applications or patents by the inventor(s) related to this invention? If so, list the serial number(s) and filing date(s).

There are no such patents or patent applications

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